

**ANNUAL ADMINISTRATIVE REPORT (FY2004) AND WORK  
PLAN (FY2005) FOR THE CAPE COD NATIONAL SEASHORE  
PROTOTYPE MONITORING PROGRAM**

**PART OF THE NORTHEAST COASTAL AND BARRIER NETWORK AND THE  
ATLANTIC AND GULF COAST BIOGEOGRAPHIC REGION**

**FY2004-FY2005**



Aquatic Ecology Technician Jon Budreski deploying a light meter - part of the kettle pond water quality monitoring project at Cape Cod National Seashore. NPS Photo.

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Northeast Region Approval Signature:

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Elizabeth Johnson, Regional Inventory and Monitoring Coordinator,      Date  
Northeast Region

Cape Cod National Seashore Approval Signatures:

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Michael Murray, Acting Superintendent      Date

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Nancy Finley, Natural Resources Chief      Date

Prepared By:

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Carrie Phillips, Inventory and Monitoring Coordinator      Date

## AARWP Checklist

	<b>Budget program (MS Access, aarwp_budget.mdb)</b>
X	The income amounts entered for Biological Inventories, Vital Signs Monitoring, Prototype \$\$ - Annual Transfer, Water Quality Monitoring and other sources matches the dollar amounts from the memos sent to the regions/networks by WASO (have you used the correct income amounts?).
X	In the Add/Edit Budget Records form, the amount shown for Total Expenses matches that for Total Income. (If it doesn't, enter a record under Expenses in the 7_Other category to make it balance; use an entry such as 'Unexpended funds' or 'Overspent Funds' in the Description column to explain the amount.)
X	For all Expense records, the Description field includes the name of the university, agency, company, or other vendor to help us document our outsourcing efforts. (If this expense involved a contract, cooperative agreement, interagency agreement, or other partnership, is it clear where the money went?)
X	For all Expense records, the correct item from the picklist for 'Where \$\$ Went' has been entered. [Think about who the check was written to; e.g., enter 'Other Non-Federal' for funding that went directly to the private sector, such as for purchases (computers, supplies, etc.), travel (airlines, rental cars, hotels).]
NA	On the Status of Biological Inventories form, there is one record for each inventory that is described in the text section of the AARWP or in the budget program. Be sure to list each park that was involved in the particular inventory.
X	Each year's budget has been exported as an .rtf file (one for FY 2004 and one for FY 2005), and both files have been inserted into MS Word at the end of the AARWP document.
X	The file aarwp_budget.mdb has been renamed to include the 4-character network alpha code and the years, as shown in this example: NCCN_FY0405_aarwp.mdb
	<b>Annual Report and Work Plan (MS Word)</b>
X	I have carefully read the guidance for the AARWP and followed it.
X	A header or footer with the date that the aarwp was last revised has been included.
X	I gave special attention to the 'Public Interest Highlights' and 'Major Accomplishments' sections of the report. (We need good examples of the successes, applications, and highlights of the program to help us obtain funding for all 32 networks! Your 'Major Accomplishments' section is what we'll use for the I&M Program's annual Report to Congress to justify the funding spent by your network.)
X	In the 'Status of Park Vital Signs Monitoring' table, all entries are equal to or greater than the entries in last year's report.
X	Photographs that might be included in one of the reports to Congress, brochures, websites, or other materials that help the program have been submitted by the network. (See the photo database and guidelines for submitting photographs.)
X	The aarwp file has been renamed using the network's 4-character alpha code and the years (FY0405) as in the example NCCN_FY0405_aarwp.doc
X	The annual report has been approved by the appropriate individuals, per my region's procedures. (If you cannot get electronic signatures, it is okay to submit a hard copy with signatures after November 8.)
X	I have followed my region's procedures for submitting the two files (e.g., NCCN_FY0405_aarwp.doc and NCCN_FY0405_aarwp.mdb). (Most regions require you to submit the files through the regional office. The files may be zipped into a zip file if desired, and then submitted to Steven Fancy via either email or ftp).
	<b>Review of FY 2005 Work Plan by WASO</b>
N/A	[Enter Yes or No]: Has the FY 2005 workplan been approved by the network Board of Directors, and therefore ready for the full WASO review? (If you enter No, the WASO I&M and WRD offices will only briefly review the work plan for 'red flags'.

## **I. Overview and Objectives**

### Ecological Context

Cape Cod is a large glacial peninsula that extends 60 miles into the Atlantic Ocean from the coast of Massachusetts. Cape Cod National Seashore (CACO) encompasses 44,600 acres of marine, estuarine, fresh water, and terrestrial ecosystems. Marine and estuarine ecosystems include barrier islands, beaches, spits, tidal flats, salt marshes, salt ponds, and soft-bottom benthos. Freshwater ecosystems include kettle ponds, vernal pools, sphagnum bogs, forested swamps, and dune slack wetlands. Terrestrial systems include pitch pine and scrub oak barrens, pitch pine forests, oak forests, heathlands, dunes, and grasslands. Many of these habitats are globally uncommon and the species that occupy them are correspondingly rare.

During the past three centuries Cape Cod ecosystems have been altered profoundly by human occupation. For example, construction of dikes and ditches in estuaries has changed natural tidal regimes resulting in water quality degradation and loss of native plant and animal species. Beach and dune stabilization efforts have interfered with natural processes shaping shorelines. Discharges from non-point sources of pollution such as landfills, septic systems, and golf courses have adversely affected surface and ground-water quality. Fire suppression has altered the distribution and volume of the heathland and pitch pine communities that predominated before European settlement. Some of the highest ozone levels in the northeast have been recorded at CACO. The park includes many municipal and private in-holdings and is surrounded by varying densities of residential and commercial development. Add the over 5 million visitors that come to CACO each year, and the significance of the challenges facing CACO managers becomes apparent.

### Program Overview

In 1996, CACO was identified as a prototype park for long-term ecosystem monitoring within the Atlantic and Gulf Coast biogeographic region. As a prototype park and in partnership with U.S. Geological Survey (USGS), CACO was charged with developing and refining long-term monitoring protocols that would support management of Cape Cod's natural resources and that could be of utility to other Atlantic and Gulf Coast parks. With the advent of the network approach to inventory and monitoring, our mission expanded to include focused technical support to the Northeast and Coastal Barrier Network (NCBN). Specifically, our role as a prototype park is to:

- develop and implement a long-term ecological monitoring program that is scientifically sound and relevant to management of park resources;
- test inventory and monitoring methods;
- develop long-term monitoring protocols relevant to CACO and to systems common among parks in the Network and the broader biogeographic region;
- conduct studies to refine monitoring questions and help interpret monitoring results; and
- share our experience and technical expertise with parks and networks nation-wide, and with the NCBN and networks in the broader biogeographic region specifically.

Development of the CACO Prototype Monitoring Program was a collaborative effort primarily between USGS and the National Park Service (NPS). USGS provided the bulk of the funding for development of a conceptual framework for the program and for protocol development. CACO began receiving funding specifically for the long-term monitoring program in 1997. Over the past seven years, this funding has been used to support continued collaboration with USGS and other cooperators on protocol development, to implement completed monitoring protocols, to initiate specific studies needed to develop monitoring approaches, to provide information and technical assistance to the NCBN and other parks in the broader biogeographic region, and to build the personnel and logistical capabilities needed for long-term monitoring.

We are currently transitioning from a developmental phase to an operational phase: of our twenty one high- and mid-priority monitoring projects, eight are now operational, protocols are being drafted for seven, and six are in development. We have developed a prioritized approach for phasing in monitoring projects as program capacity allows, filled our key permanent and term positions, made substantial investments in durable lab and field equipment, and have made significant progress on a comprehensive data management system. Over the next few years, our attention will be focused on implementing our highest priority projects, phasing in our mid-priority projects as program capacity allows, and completing and maintaining the data management system.

The CACO Prototype Monitoring Program is also exploring ways to partner and integrate with the Atlantic Research Learning Center (ARLC), another element of the Natural Resource Challenge also located at Cape Cod National Seashore. We have already seen substantial benefits from a mutualistic approach to management of these two highly related programs. For example:

- the ARLC has provided housing to several cooperators working on protocol development allowing monitoring program dollars to stretch further;
- protocol development has attracted externally funded research such as a Fowler's toad study being conducted by one of the cooperators who developed the amphibian monitoring protocol; and
- ARLC funding has supported three University of Rhode Island Coastal Fellows monitoring the benthic community's response to restoration of tidal influence in East Harbor; faculty participation and oversight for the project is provided by the cooperator developing the benthic monitoring protocol.

As the monitoring program matures, and as ARLC facilities and partnerships develop, we anticipate that the synergy between the two programs will grow, particularly with respect to attracting and supporting research that expands on the results of long-term monitoring.

### Objectives

Our program objectives are listed below. The ecosystem approach for organizing our monitoring objectives (objectives 1-6) is based on the *Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore* (Roman and Barrett 1999) and its 2002 Update (Boland *et al.* 2002). These documents also describe the conceptual models used to select specific monitoring components, provide justification for each monitoring project, enumerate the specific monitoring

questions being addressed, and identify the parameters being measured. Selection of the specific activities planned under these objectives has been guided by the project prioritization and implementation scheme described in *2003 Cape Cod National Seashore LTEM Project Prioritization Report* (Phillips 2003). Objectives seven through eight address information sharing, reporting, and technical support to other monitoring programs. Objective nine focuses on program management and infrastructure, and has been revised since last year to specifically include data management.

#### Cape Cod Prototype Monitoring Program Objectives:

1. Assess and monitor the integrity of estuarine and salt marsh ecosystems.
2. Assess and monitor the integrity of beach, spit, and barrier island ecosystems.
3. Assess and monitor the integrity of pond and freshwater wetland ecosystems.
4. Assess and monitor the integrity of coastal upland ecosystems.
5. Assess and monitor park-wide and multiple-system indicators of ecosystem integrity.
6. Integrate monitoring efforts and results within and across ecosystems.
7. Share information, report findings, and document program activities.
8. Provide technical assistance to the NCBN, to other networks and parks, and to other entities with common monitoring objectives.
9. Develop and sustain a comprehensive data management program and appropriate staff resources, laboratory infrastructure, and programmatic procedures to ensure program objectives can be met now and into the future.

## **II. Accomplishments (FY2004) and Scheduled Activities (FY2005)**

Objective 1 - Assess and monitor the integrity of estuarine and salt marsh ecosystems: The accomplishments and planned activities in Tasks 1.1, 1.2, 1.4, and 1.5 contribute to the estuarine restoration goals in CACO's General Management Plan (GMP) (NPS 1998).

#### *Task 1.1 - Monitor salt marsh sediment elevation response to sea level rise*

##### FY2004 Accomplishments:

- Salt marsh accretion, erosion, and relative elevation were measured at established sediment elevation table (SET) sites in three estuaries (Hatches Harbor, Nauset Marsh, Herring River/Wellfleet Bay)
- In early FY2004, we conducted site visits with Dr. Don Cahoon (USGS) to evaluate the utility and feasibility of adding SET sites at three additional estuaries at CACO (Pleasant Bay, East Harbor, West End Marsh) and adding or converting to "deep SET" configurations. Recommendations and priorities for expanding our existing SET network will be included in the formal protocol Dr. Cahoon is developing for this project; protocol development is supported by USGS Prototype Development funds. Bryan Milstead and Mark Duffy (NCBN) also participated to learn more about the SET monitoring and consider its potential applicability to Network monitoring goals.
- Results from SET monitoring in Hatches Harbor were presented in an article in *Park Science on the Hatches Harbor restoration project* (Portnoy *et al.* 2003a).

Scheduled FY2005 Activities:

- In FY2005, we will continue to collect accretion, erosion, and relative elevation measurements at established SET sites in three estuaries (Hatches Harbor, Nauset Marsh, Herring River/Wellfleet Bay).
- Sediment elevation monitoring methods are well established and documented by USGS; however, application of these methods at CACO has not been documented in a formal protocol. Dr. Don Cahoon (USGS) is developing a protocol which will apply to CACO and will provide guidance for developing sediment elevation monitoring programs at other parks in the NCBN and larger biogeographic region. We expect a draft to become available in early FY2005; at that time, we will provide review and comment, and collaborate with Dr. Cahoon and the NCBN to finalize the protocol.

*Task 1.2 - Map intertidal habitats with an emphasis on estuarine systems*

FY2004 Accomplishments:

- The Environmental Data Center (EDC) at the University of Rhode Island (URI) completed the intertidal habitat mapping project initiated in FY2002. This project focused on the intertidal habitats of Nauset Marsh, Wellfleet Harbor, and Hatches Harbor. Habitats were characterized by a variety of features including sediment properties in unvegetated areas. Final products include spatial data (habitat coverage, geographic positioning system (GPS) points, photo locations, sampling locations), FGDC-compliant metadata, and a report documenting methods (Bradley *et al.* 2004). This project was funded by the CACO Prototype Monitoring Program in FY2002 through a Northeast Region Task Agreement with the URI EDC.

Scheduled FY2005 Activities:

- The results of this project will be included in the remote sensing-based cover-type mapping project planned for 2005 (please see Task 5.3)

*Task 1.3 - Monitor estuarine nutrient enrichment*

FY2004 Accomplishments:

- In FY2004, we continued collaboration with Drs. Hilary Neckles and Blaine Kopp (USGS), Dr. Charles Roman with the North Atlantic Coast Cooperative Ecosystems Studies Unit (CESU), Dr. Barbara Nowicki (URI), and the NCBN on development of Network-wide and CACO-specific elements of a nutrient enrichment monitoring protocol. Drs. Neckles and Kopp are funded by the NCBN; Drs. Roman and Nowicki are supported by USGS Prototype Development funds.

Scheduled FY2005 Activities:

- A draft protocol for this project is expected in early FY2005; we will provide review and comment on the document and will assist the principal investigators and the NCBN to finalize the protocol.
- Following review of the draft protocol, we will begin planning and purchasing as needed to establish sampling sites and begin deploying instruments with a goal of initiating full implementation of the protocol in FY2006. In FY2005, we may also begin implementation of the submerged aquatic vegetation monitoring element of the protocol pending further coordination with Drs. Neckles and Kopp.

#### Task 1.4 - Monitor salt marsh vegetation

##### FY2004 Accomplishments:

- Finished collecting salt marsh site characterization data (elevation and depth to water table at low tide for all plots) to complete the 2003 salt marsh monitoring effort.
- Created a new Access database for salt marsh vegetation monitoring data. This data base was developed in partnership with the NCBN who is using the same salt marsh vegetation monitoring protocol.
- Completed the first monitoring report for this project. The report documents the work performed, and presents and interprets results through the 2003 field season (Smith 2004a). Results from salt marsh vegetation monitoring in Hatches Harbor were also presented in an article in Park Science on the Hatches Harbor restoration project (Portnoy *et al.* 2003a).
- In collaboration with Dr. Scott Warren, Connecticut College, developed an inexpensive and time-efficient method for determining elevations in tidal marshes using a water mark technique.
- Continued monitoring vegetation response to restoration activities at Hatches Harbor and East Harbor as guided by the protocol (Roman *et al.* 2001).
- Began monitoring the recovery of widgeon grass (*Ruppia maritima*) in the restoring East Harbor system. The two components of the *R. maritima* project are mapping *R. maritima* beds within East Harbor, and monitoring indices of abundance and vigor at five randomly selected locations around the perimeter of East Harbor using methods adapted from the submerged aquatic vegetation element of the estuarine nutrient enrichment project.
- Established half of the planned vegetation monitoring transects in the Herring River system in anticipation of tidal restoration. Herring River will be integrated into the overall salt marsh vegetation monitoring program as the restoration project proceeds.
- Initiated spatially-intensive monitoring of salt marsh die-back patches in Middle Meadow and The Gut. These areas of salt marsh die-back were first observed during salt marsh monitoring activities in 2003. This is the first instance of salt marsh die-back detected within the park. Photo points were also established at several other sites to detect any future occurrences of die-back.

##### Scheduled FY2005 Activities:

- Prepare a monitoring report on the salt marsh vegetation monitoring work completed in FY2004.
- Submit a note to a peer-reviewed publication on the water mark technique for measuring elevations in marshes.
- The NCBN is currently converting the CACO salt marsh vegetation monitoring protocol to the new format required by the National Inventory and Monitoring (I&M) Program, and adapting it as needed to apply to other Network parks. In FY2005, we will collaborate with the NCBN to include the CACO-specific elements of this monitoring project in the revised protocol.
- Continue to monitor salt marsh vegetation response to restoration of marine influence in East Harbor.
- Establish the remaining vegetation monitoring transects in the Herring River system.



- Continue monitoring the salt marsh die-back observed in Middle Meadow and The Gut. In addition, and in partnership with the ARLC, we hope to interest other researchers in developing a more in-depth collaborative study on the extent, nature, and causes of salt marsh die-back on the Cape.

*Task 1.5 - Monitor estuarine benthos and nekton*

FY2004 Accomplishments:

- Provided technical assistance and logistical support to the investigator (Sheldon Pratt, URI) developing the estuarine benthos monitoring protocol. In this second full year of the project, efforts focused on additional field sampling and processing, prioritizing monitoring question, and statistical analysis. We expect a draft final report and protocol in FY2005. This project is supported by CACO Prototype Monitoring Program (FY2002) and USGS Prototype Development funds through a cooperative agreement between USGS and URI.
- Results from nekton monitoring in Hatches Harbor were presented in an article in Park Science on the Hatches Harbor restoration project (Portnoy *et al.* 2003a)
- Continued monitoring nekton response to the restoration of marine influence in East Harbor and Hatches Harbor, and initiated pre-restoration monitoring in the Herring River system. Monitoring methods are described in the nekton monitoring protocol (Raposa and Roman 2001). NCBN assisted with nekton monitoring at Hatches Harbor.
- Collaborated with the ARLC to bring two URI Coastal Fellows to the park to monitor the response of the benthic community to restoration in East Harbor.
- Collaborated with the NCBN to initiate nekton monitoring at Nauset Marsh. This is the first year of a five year effort to improve estimates of annual variability in order to refine the sampling frequency recommended in the protocol.

Scheduled FY2005 Activities:

- Provide technical support, review, and comment as necessary to assist Dr. Pratt in producing a draft final report and protocol for monitoring estuarine benthos.
- Prepare a report on the nekton monitoring work done in 2003 and 2004.
- Continue monitoring nekton at Nauset Marsh in collaboration with the NCBN.
- Continue monitoring nekton response to tidal restoration at Hatches Harbor, East Harbor, and Herring River.

Objective 2 - Assess and monitor the integrity of beach, spit, and barrier island ecosystems.

The accomplishments and planned activities in Task 2.1 implement the long-term monitoring strategy under the Coastal Processes Goal in CACO's GMP.

*Task 2.1 - Develop geomorphic shoreline change monitoring protocol*

FY2004 Accomplishments:

- Provided technical assistance to the NCBN in their effort to develop a shoreline change monitoring protocol.

Scheduled FY2005 Activities:

- Continue to support the Network's efforts and increase CACO's involvement in protocol development and testing. We expect a draft protocol for the GPS-based portion of this monitoring project to become available during the first quarter of FY2005. We will provide review and comment on the draft and assist the NCBN to

finalize this portion of the protocol. We will also work with the NCBN to coordinate flight lines and ground-based operations for acquisition of light distance and ranging (LIDAR) data during the fall or winter of FY2005.

*Task 2.2 - Monitor beach and barrier island nesting birds*

FY2004 Accomplishments:

- CACO's Division of Natural Resource Management (NRM) monitored the breeding population and productivity of piping plovers (*Charadrius melodus*) at CACO. This monitoring project was initiated in 1985 and is funded with NRM base funds.
- NRM also monitored breeding populations and nesting effort of beach-nesting colonial waterbirds.
- Provided technical assistance on database design and data management, and logistical support for the second year of the piping plover disturbance monitoring study initiated last year. This project is funded by the CACO Prototype Monitoring Program (FY2003) and the Over-Sand Vehicle Permit Program through the CESU. The principal investigator is Scott McWilliams at URI.

Scheduled FY2005 Activities:

- NRM will continue to monitor piping plover and beach-nesting colonial waterbird productivity.
- In FY2005, the principle focus of the plover disturbance monitoring study will be data analysis and reporting. If preliminary analysis indicates additional field work is necessary, we will provide technical assistance and logistical support as needed.

Objective 3 - Assess and monitor the integrity of pond and freshwater wetland ecosystems.

All the tasks associated with this objective further the strategies described in CACO's GMP for protecting water quality, water quantity, and wetlands.

*Task 3.1 - Characterize dune slack wetlands and evaluate long-term monitoring needs*

FY2004 Accomplishments:

- Implemented the second year of this 2-year study. Year 2 activities included refinement of landscape parameters, continued hydrologic monitoring, and repeated physical, chemical, and biological sampling. This is a joint project with NRM and is supported by competitive funds from NPS-Water Resource Management Division (WRD).

Scheduled FY2005 Activities:

- Complete data analysis and reporting on the dune slack characterization study. The report will include recommendations for future monitoring and may indicate methods that should be considered for woodland vernal pool monitoring.

*Task 3.2 - Monitor kettle pond water quality and limnology*

FY2004 Accomplishments:

- Collected water quality monitoring data from all 20 CACO kettle ponds as guided by the protocol (Portnoy *et al.* 2003b)
- Modified and improved the existing kettle pond data base.
- Tested periphyton monitoring methods for possible incorporation into the kettle pond monitoring project.

Scheduled FY2005 Activities:

- A major focus of our activities in FY2005 will be a rigorous review of recent (since the inception of the CACO Prototype Monitoring Program) and historic (extending back over 20 years) kettle pond monitoring data. USGS Biological Resources (BRD) and Water Resources (WRD) Divisions will be providing assistance with statistical analysis. At a minimum, this review will culminate in a peer-reviewed technical report (targeted for late FY2005 or early FY2006). If protocol revision is indicated, the technical report will form the basis of the narrative section of a revised protocol, and the protocol document will be converted to the new format. We anticipate protocol revision would occur in FY2006.
- Continue annual monitoring at all ponds according to the current protocol. We will not implement any changes in the field until the review and protocol revision have been peer reviewed.

*Task 3.3 - Monitor pond vegetation*

FY2004 Accomplishments:

- Continued monitoring the response to two exotic plant control projects targeting purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*).
- Submitted a paper on manual control of *P. australis* on pond shores to the Journal of Aquatic Plant Management which is currently in review (Smith 2004b).

Scheduled FY2005 Activities:

- Initiate intensive method testing and related field experimentation for development of a pond vegetation monitoring protocol. Completion of a draft protocol is planned for FY2006.

*Task 3.4 - Inventory and develop a monitoring protocol for freshwater aquatic invertebrates*

FY2004 Accomplishments:

- Continued to provide technical assistance and logistical support to the principal investigator developing this protocol (Dr. Elizabeth Colburn, Harvard Forest). We also added \$3734 to the existing cooperative agreement to support additional work on midges (*Chironomus decorus*). This project was initiated in FY2002 and is supported by CACO Prototype Monitoring Program funds.

Scheduled FY2005 Activities:

- Continue to provide technical assistance and logistical support as needed. Provide review and comment on a draft report and protocol if they become available in FY2005 (more likely to be available in FY2006).

*Task 3.5 - Inventory and monitor amphibians*

FY2004 Accomplishments:

- Prepared a monitoring report describing the amphibian monitoring work completed in 2003 (Cook and Boland 2004a), and comparing two methods of conducting egg mass counts. A note on the egg mass count method comparison is currently in press in Herpetological Review (Cook and Boland 2004b).
- Conducted the second year of monitoring according to the protocol completed in 2003 (Paton *et al.* 2003). This included implementing the egg mass count component at 20 sites and the anuran call count component at 30 sites.

- In addition to conducting the egg mass counts according to the long-term monitoring protocol, we also conducted egg mass counts at an additional 20 ponds as part of the USGS-BRD Amphibian Research and Monitoring Initiative (ARMI) program.
- Modified and improved the existing amphibian data base.

Scheduled FY2005 Activities:

- Prepare a monitoring report describing the work conducted in 2004.
- Implement the third year of amphibian monitoring according to the protocol.
- Implement the second year of the USGS-ARMI project at CACO.
- Complete a report on the terrestrial salamander inventory work conducted in FY2000 and 2001.

*Task 3.6 - Inventory and monitor aquatic turtles*

FY2004 Accomplishments:

- Completed a draft report on an aquatic turtle study conducted from 1999 through 2003 (Cook *et al.* 2004). The report provides detailed information on aquatic turtle distribution, abundance, and habitat affinity, and assesses the feasibility of long-term monitoring.
- Modified and improved the existing turtle data base.

Scheduled FY2005 Activities:

- Obtain peer review and finalize the aquatic turtle report.

Objective 4 - Assess and monitor the integrity of coastal upland ecosystems.

The accomplishments and planned activities under Task 4.2 are integral to development of the heathland management plan called for in CACO's GMP.

*Task 4.1 - Characterize dune habitat parameters and develop a dune grassland vegetation monitoring protocol*

FY2004 Accomplishments:

- Completed and published a paper on characterizing the microbiotic crusts of CACO's dunes (Smith *et al.* 2004).
- Conducted preliminary field studies to develop long-term grassland vegetation monitoring methods.

Scheduled FY2005 Activities:

- Continue development and field testing of monitoring methods.

*Task 4.2 - Develop a monitoring protocol for coastal heathlands*

FY2004 Accomplishments:

- Completed an in-depth report on protocol development work in the form of a Master's thesis (Gwilliam 2004). This report will comprise the narrative portion of the heathland monitoring protocol.

Scheduled FY2005 Activities:

- Develop the SOPs needed to complete the draft protocol, and forward to the Regional I&M Coordinator for peer review.
- Begin drafting a heathland management plan based on the research done during protocol development.

#### *Task 4.3 - Monitor coastal forest vegetation*

##### FY2004 Accomplishments:

- Completed a draft protocol for monitoring coastal forest vegetation (Smith and Potash 2004). The draft has undergone internal review and will be forwarded to the Regional I&M Coordinator for peer review during the first quarter of FY2005.
- Created a data base for the forest vegetation monitoring project.
- Continued collaboration with the University of Massachusetts (UMass) to analyze change in forest structure and composition based on three data sets collected between 1981 and 2002. This project was funded last year with CACO Prototype Monitoring Program funds and a report from UMass is expected during the first quarter of FY2005.

##### Scheduled FY2005 Activities:

- Finalize the protocol based on peer reviewer comments.

#### *Task 4.4 - Inventory terrestrial reptile.*

##### FY2004 Accomplishments:

- Continued monitoring Eastern box turtles (*Terrapene carolina carolina*) through incidental encounters.
- Modified and improved the existing reptile data base.

##### Scheduled FY2005 Activities:

- Complete a report on the snake inventory work conducted in FY2001 and 2002.

#### *Task 4.5 - Monitor land birds*

##### FY2004 Accomplishments:

- Received a final report on the Monitoring Avian Productivity and Survivorship (MAPS) project initiated in 1999 (DeSante *et al.* 2004).
- Provided technical assistance and logistical support to Manomet Center for Conservation Sciences for a northern harrier (*Circus cyaneus*) inventory initiated in FY2003 and supported by CACO Prototype Monitoring Program funds. This was the first full year of a two-consecutive field season study.

##### Scheduled FY2005 Activities:

- Continue to provide technical assistance and logistical support to Manomet as needed to complete the second field season of the northern harrier inventory.
- We expect a draft monitoring protocol based on point counts to become available from cooperators at UMass; we will provide the review and assistance necessary to complete the protocol.

#### *Task 4.6 - Assess the feasibility of small mammal monitoring*

##### FY2004 Accomplishments:

- Obtained peer review on a draft report evaluating the utility and feasibility of a small mammal monitoring protocol based on a two-year field testing phase (Cook and Boland 2003).

##### Scheduled FY2005 Activities:

- Finalize the small mammal report in light of reviewers' comments.

*Task 4.7 - Develop a protocol for long-term meso-mammal monitoring*

Scheduled FY2005 Activities:

- In FY204, Dr Allan O'Connell with USGS-BRD received USGS funding to develop a meso-mammal monitoring protocol. In FY2005, we will be providing technical assistance and logistical support for the field portion of the protocol development study.

Objective 5 - Assess and monitor park-wide and multiple-system indicators of ecosystem integrity. The accomplishments and planned activities noted in Task 5.1 implement the research, monitoring, and effects detection strategies in CACO's GMP under the Air Resources Goal; those in Task 5.2 contributes to the water quality and quantity protection strategies in CACO's GMP; and those in Task 5.3, together with the array of vegetation monitoring activities described throughout this report and work plan, are part of the native plant and wildlife habitat restoration strategy described under the biotic resource management goal in CACO's GMP.

*Task 5.1 - Monitor meteorologic, atmospheric deposition, and air quality parameters*

FY2004 Accomplishments:

- Monitored precipitation and atmospheric deposition through National Atmospheric Deposition Program (NADP) and the Mercury Deposition Network (MDN), aerosols through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, and ozone in partnership with the State.

Scheduled FY2005 Activities:

- Continue to monitor precipitation, atmospheric deposition including mercury, aerosols, and ozone.
- Revise the meteorologic and atmospheric monitoring protocol (USGS, URI, CACO 2001) to update in-park procedures, update links to partner data sources and procedures, specify the frequency for downloading data from other sources, address data management, and conform to the new format for monitoring protocols.

*Task 5.2 - Monitor hydrology and ground water quality*

FY2004 Accomplishments:

- Initiated implementation of the ground water and pond stage portion of the protocol completed in FY2003 (McCobb and Weiskel 2003).
- Began field testing the stream flow portion of the hydrology protocol. We found application of standard stream gauging techniques in tidally-influenced systems to be somewhat problematic and have secured technical assistance from the protocol authors and others at USGS-WRD to help us revise this portion of the protocol.
- Provided review and comment on a draft ground-water quality monitoring protocol prepared by USGS-WRD (Colman 2004). This protocol effort was initiated in FY2002 with CACO Prototype Monitoring Program funds.

Scheduled FY2005 Activities:

- Resolve difficulties with the stream flow portion of the hydrology protocol and draft an addendum reflecting the revised methods.
- If time allows, we may revise the entire hydrology monitoring protocol to conform to the new format standards.

- Provide additional review and technical assistance as needed to complete the ground-water quality monitoring protocol.
- If time allows, we may initiate implementation of the ground-water quality monitoring protocol.

*Task 5.3 - Complete the cover-type map and develop a long-term approach for cover-type change monitoring*

FY2004 Accomplishments:

- Received and corrected the final digitized vegetation polygons from the cooperator at UMass and received the final vegetation classification report and draft field data from NatureServe (Sneddon and Zaremba 2004). This project was initiated in FY2001 and has been supported by CACO Prototype Monitoring Program funds and funds from the National Vegetation Mapping program through the Regional I&M coordinator.
- Received \$44,800 from the National Vegetation Mapping program through the Regional I&M Coordinator to conduct a thematic accuracy assessment of the cover-type map. These funds were obligated to NatureServe, and field work was initiated this year.

Scheduled FY2005 Activities:

- Provide technical and logistical support as needed to help NatureServe finalize the field data and complete the accuracy assessment. Production of a draft report is scheduled for the first quarter of FY2006.
- In FY2005 and 2006, in collaboration with the NCBN, we plan to investigate transitioning from aerial photography to high resolution satellite data for monitoring cover-type change. The NCBN is currently conducting a pilot project at FIIS using Quick Bird 2 multi-spectral satellite remote sensing data; we will base our approach on the results and lessons learned from the FIIS project.

*Task 5.4 - Develop a protocol for monitoring the effects of visitation*

Scheduled FY2005 Activities:

- This project was initiated in FY2000 with support from USGS Prototype Development funds, and field work was conducted in 2001. The results have not yet been made available. Since that time, the NCBN has conducted a study assessing visitor use monitoring needs for the seven other parks in the Network. In FY2005, we will collaborate with the NCBN to integrate the results of the two studies, contract for any additional work that might be necessary, and develop a protocol that meets CACO's needs and is integrated with the approach taken throughout the Network.

## Objective 6 - Integrate monitoring efforts and results within and across ecosystems

*Task 6.1 - Enhance commonalities and coordination among protocols*

FY2004 Accomplishments:

- Development of the coastal forest vegetation and coastal heathland draft protocols occurred in close coordination to ensure data integrity and seamless transition of monitoring as heathland sites succeed to forest in future years.

Scheduled FY2005 Activities:

- As the ground-water quality protocol is finalized, special attention will be paid to the sites and parameters selected to maximize operational overlap with the ground-water portion of the hydrology protocol, and to provide opportunities for future integrative analyses with kettle pond water quality data.

*Task 6.2 - Integrate analysis of monitoring results*

FY2004 Accomplishments:

- Synthesized monitoring data in a report on the response of sediment elevation, vegetation, nekton, and physical/chemical parameters to restoration of tidal influence at Hatches Harbor (Portnoy *et al.* 2003a).

Objective 7 - Share information, report findings, and document program activities.

*Task 7.1 - Share information with non-technical audiences*

FY2004 Accomplishments:

- Conducted training sessions for seasonal interpretive staff.
- Staff gave presentations about the program and the results of monitoring activities to a variety of public groups. Audiences included; the Pleasant Bay Alliance, the Nantucket Consortium of Naturalists, a Bridgewater State College hydrology class, Massachusetts Audubon, and visitors to the Province Lands Visitors' Center.

Scheduled FY2005 Activities:

- Continue to provide information through training, presentations, articles or other appropriate venues as opportunities arise.

*Task 7.2 - Share technical information with scientists, NPS audiences, and other entities interested in monitoring and resource management*

FY2004 Accomplishments:

- In addition to the reports and articles mentioned under other objectives, staff and cooperators gave presentations on program projects at the Data Manager's Conference, the Cape Cod Natural History Conference, the University of Rhode Island, the annual meeting of the New England Chapter of the Society for Environmental Toxicology and Chemistry, and the annual American Society of Mammalogists Conference.

Scheduled FY2005 Activities:

- Continue to share program results and other technical information through presentations, posters, workshops, and other appropriate venues as opportunities arise.
- Reorganize and update the program's web site to facilitate sharing reports, data, and other program information.

*Task 7.3 - Document program activities and findings*

The specific reporting accomplishments and planned activities identified throughout this report and work plan are summarized below; citations are provided in Section IV.

FY2004 Accomplishments:

- Completed the following project reports and protocols:
  - report on salt marsh sediment elevation, nekton, and vegetation monitoring results at Hatches Harbor
  - salt marsh vegetation monitoring report for activities through 2003
  - amphibian monitoring report for activities through 2003
  - draft aquatic turtle inventory report
  - microbiotic crust characterization paper
  - draft paper on manual control of *Phragmites australis* on pondshores
  - MAPS final report (prepared by cooperator)
  - vegetation classification report (prepared by cooperator)



- intertidal habitat map report (prepared by cooperator)
- heathland monitoring design report (thesis which will comprise the narrative section of the protocol)
- draft coastal forest monitoring protocol
- draft ground-water quality monitoring protocol (prepared by cooperator)

Scheduled FY2005 Activities:

- Complete the following project reports and protocols:
  - salt marsh vegetation monitoring report on 2004 activities
  - estuarine nekton monitoring report on 2003 and 2004 activities
  - dune slack wetland characterization report
  - amphibian monitoring report on 2004 activities
  - kettle pond water quality review report
  - finalize small mammal report
  - finalize aquatic turtle inventory report
  - terrestrial salamander inventory report
  - snake inventory report
  - salt marsh sediment elevation protocol (with cooperator)
  - salt marsh vegetation protocol revision (with NCBN)
  - GPS portion of the shoreline change protocol (with NCBN)
  - finalize coastal forest vegetation protocol
  - heathland monitoring protocol
  - land bird point-count protocol (with cooperator)
  - meteorologic and atmospheric protocol revision
  - finalize ground-water quality protocol (with cooperator)
  - stream-flow addendum to hydrology protocol

Objective 8 - Provide technical assistance to other networks and parks, and to other entities with common monitoring objectives.

*Task 8.1 - Share technical expertise with other networks and parks*

FY2004 Accomplishments:

- In partnership with the NCBN, developed a white paper on database models for use by the NRDT Database Structure Design Group and other data managers (Potash and Huse 2004)
- Contributed to several data management work groups including those working on database structure design for the database template, development of database standards, image management, conceptual modeling for data management, and development of a template for data management plans, including drafting chapters four and six for the data management plan template.
- Provided review and comment on the vegetation mapping report for HOFU.
- Provided technical leadership on the herptofaunal inventory project covering ten NPS units in the Northeast Region. This project is funded by the Northeast Region and is being conducted in partnership with the Wildlife Conservation Society. FY2004 activities included a field visit to ASIS to reconnoiter the site and assist in developing an inventory work plan, rewrote the draft of the ACAD herptofaunal inventory report,

contributed to a report on the use of DEWA by timber rattlesnakes, and collaborated on a paper on range contraction and population decline of dusky salamanders at ACAD.

- The analytical lab, which is supported by the NRM Division and the Prototype Monitoring Program, provided analytical support and technical assistance to GATE for sulfide analysis of salt marsh porewater samples.

Scheduled FY2005 Activities:

- Continue to participate and provide technical assistance to various data management work groups and projects.
- Help finalize the inventory reports for DEWA, MORR, WEFA, MIMA, SARA, SAIR, SAGA, WIFL, FIIS, and ASIS; and begin analysis and reporting on the GATE inventory.
- Continue to provide other types of technical assistance as opportunities arise.

*Task 8.2 - Provide technical assistance to other monitoring efforts*

FY2004 Accomplishments:

- Collected samples for Barnstable County's freshwater quality monitoring project and for UMass Dartmouth's Cape Cod Estuary Project.
- The analytical lab, which is supported by the NRM Division and the Prototype Monitoring Program, provided analytical support and technical assistance to Massachusetts Coastal Zone Management's Salem Sound Nutrient Monitoring Project, Massachusetts Audubon's water quality monitoring project, and the Martha's Vineyard Commission's Pond Monitoring Project.

Scheduled FY2005 Activities:

- Continue to provide technical and analytical assistance as time and resources allow.

Objective 9 - Develop and sustain a comprehensive data management program and appropriate staff resources, laboratory infrastructure, and programmatic procedures to ensure program objectives can be met now and into the future.

*Task 9.1 - Build and maintain a comprehensive data management program*

FY2004 Accomplishments:

- Established a basic file structure, naming guidance, and archiving procedures for electronic files and re-organized the server accordingly. Completed an audit of project files to measure progress toward the new file structure.
- Developed Access database structures and screen designs that can be modified for use with any protocol. These structures were put into use in the revised or newly created databases for amphibians, reptiles, kettle ponds, coastal forest vegetation, and salt marsh vegetation.
- Established standards for Access code documentation, image file management, and data quality assurance audits.
- Developed a database design requirements specification questionnaire to assist with database design and metadata creation.
- Assessed CACO's status with respect to NPSpecies and developed a plan for validating and populating CACO's contribution to the database.
- Assisted CACO's System Administrator to repair and maintain the server.

Scheduled FY2005 Activities:

- Develop a Data Management Plan and associated standard operating procedures (SOP) based on the data management plan template being developed by the first twelve networks.
- Refine the basic file structure developed in 2004, and continues clean-up and maintenance of electronic files on the server.
- Develop Access databases as protocols are developed. Likely candidates for new or revised databases in 2005 are the salt marsh sediment elevation, coastal heathland vegetation, hydrology, and meteorology and atmospheric monitoring protocols.
- Validate CACO's wildlife portion of NPSpecies and begin populating and validating the plant portion of NPSpecies.
- Initiate development of a species identification and voucher image database.

*Task 9.2 - Build technical expertise and work force capacity that promotes consistency in monitoring project implementation*

FY2004 Accomplishments:

- Hired a GS-11 Data Manager.
- Hired a 4-year term GS-7 Hydrology Technician.

Scheduled FY2005 Activities:

- Convert the Hydrology Technician and Aquatic Ecology Technician positions from term to permanent.

*Task 9.3 - Secure an adequate work force to complete scheduled field and laboratory tasks*

FY2004 Accomplishments:

- Hired four seasonal BioTechs for the following projects:
  - amphibian monitoring
  - salt marsh monitoring
  - dune slack wetland study (supported by funds from NPS-WRD)
  - GIS support
- Recruited and supported three Student Conservation Association (SCA) volunteers and one volunteer through the Volunteers-In-Parks (VIP) program to assist with the projects listed above, and with the kettle pond water quality monitoring project.

Scheduled FY2005 Activities:

- Hire four seasonal BioTechs for the following projects:
  - amphibian monitoring (2)
  - pond vegetation protocol development
  - GIS support
- Recruit and support five SCAs, VIPs, or other interns to assist with the projects listed above, with kettle pond water quality monitoring, and with populating NPSpecies.

*Task 9.4 - Develop and maintain the analytical laboratory's infrastructure and capabilities*

The following accomplishments and activities are directed by the NRM Chemist with assistance from the monitoring program.

FY2004 Accomplishments:

- Continued participation in the USGS Standard Reference Sample (SRS) Program for quality assurance for nutrient and trace element analyses. All samples submitted to the SRS Program received acceptable rating values.

- Completed method development for analysis of iron and manganese in water by graphite furnace atomic absorption spectrophotometry.
- Completed method development for low-level phosphorus, nitrate, and anions by rapid ion chromatography.
- Completed updates and review of methods for the Lab Handbook of Analytical Methods.
- Increased analytical capabilities through equipment purchases and upgrades.
- Reorganized and archived laboratory data, methods, safety protocols, and quality assurance procedures in collaboration with the Data Manager.

Scheduled FY2005 Activities:

- Continue participation in the USGS Standard Reference Sample Program.
- Maintain and update the lab Handbook of Analytical Methods as needed.
- Initiate additional method development and oversee equipment purchases and upgrades as needed to support monitoring efforts. Method development and additional analytical capability needs will likely be identified as the ground-water monitoring protocol nears completion.

*Task 9.5 - Develop programmatic standard operating procedures for monitoring project elements common to all or most protocols*

FY2004 Accomplishments:

- Completed draft Programmatic SOP guidance, a draft programmatic SOP for monitoring project safety, and a draft safety SOP for the Coastal Forest Monitoring Protocol as an example of how the programmatic SOP approach will work.

Scheduled FY2005 Activities:

- Finalize the Programmatic SOP Guidance and programmatic SOPs for safety, reporting, protocol review and revision, and use of GPS.

### **III. Staffing**

#### CACO Prototype Staff

Carrie Phillips, Prototype Coordinator  
 Velma Potash, Data Manager  
 Chris Pearson, Budget Assistant  
 Robert Cook, Wildlife Ecologist  
 Stephen Smith, Plant Ecologist  
 Evan Gwilliam, Aquatic Ecologist  
 Kelly Boland, Wildlife BioTech  
 Jon Budreski, Aquatic Ecology BioTech  
 Kelly Morris, Hydrology Tech

#### CACO Natural Resource Management Staff

Many critical program functions are also carried out by the Division of Natural Resource Management. The individuals listed below provide management oversight, GIS support, laboratory management, piping plover and colonial waterbird monitoring, and expertise

in chemical analysis, biogeochemistry, and ecology. This year, extensive support from the Senior Ecologist, GIS Specialist, and Chemist was required for several high priority monitoring projects.

Nancy Finley, Division Chief

John Portnoy, Senior Ecologist

Mark Adams, GIS Specialist

Krista Lee, Chemist

Judith Oset, Laboratory Tech

Mary Hake, Plover and Colonial Waterbird BioTech

Katy Kughen, Plover and Colonial Waterbird BioTech

Primary Science Advisors:

Charles Roman, Research Coordinator, NAC CESU

Don Cahoon, USGS-BRD, Patuxent Wildlife Research Center

Cooperators:

Raeid Abed, Max Planck Institute for Marine Microbiology (dune crust characterization)

Mike Bradley, University of Rhode Island (inter-tidal mapping project)

Rhys Bowen, independent contractor to Manomet Center for Conservation  
Sciences (harrier inventory)

Elizabeth Colburn, Harvard Forest (freshwater aquatic invertebrate protocol)

John Colman, USGS-WRD, MA-RI District (ground-water quality protocol)

David DeSante, Institute for Bird Populations (MAPS project)

Leslie DeSimone, USGS-WRD, MA-RI District (kettle pond protocol review)

Ferran Garcia-Pichel, Arizona State University (dune crust characterization)

Howard Ginsberg, USGS-BRD, Patuxent Wildlife Research Center (beach  
macroinvertebrate protocol)

Curtice Griffin, University of Massachusetts, Amherst (landbird point-count protocol)

Mary-Jane James-Pirri, Graduate School of Oceanography, University of Rhode Island  
(salt marsh vegetation and nekton protocols)

Blaine Kopp, USGS, Patuxent Wildlife Research Center (estuarine nutrient  
enrichment protocol)

Charles LaBash, University of Rhode Island (inter-tidal mapping project)

Jeff Marion, USGS, Patuxent Wildlife Research Center (visitor impact protocol)

John Masterson, USGS-WRD, MA-RI District (hydrology and ground-water  
quality protocols)

Scott McWilliams, University of Rhode Island (plover disturbance monitoring study)

Hilary Neckles, USGS, Patuxent Wildlife Research Center (estuarine nutrient  
enrichment protocol)

Barbara Nowicki, Graduate School of Oceanography, University of Rhode Island  
(estuarine nutrient enrichment protocol)

Allan O'Connell, USGS, Patuxent Wildlife Research Center (meso-mammal protocol)

Candace Oviat, Graduate School of Oceanography, University of Rhode Island (estuarine  
nutrient enrichment protocol)

Peter Paton, University of Rhode Island (amphibian monitoring, egg mass count  
method revision)

William Patterson, University of Massachusetts (forest vegetation monitoring protocol)  
Donna Peterson, University of Massachusetts (cover-type mapping project)  
Sheldon Pratt, Graduate School of Oceanography, University of Rhode Island  
(estuarine benthic macrofauna protocol)  
Leslie Sneddon, NatureServe (cover-type mapping project)  
Scott Warren, Connecticut College (salt marsh elevation method development)  
Peter Weiskel, USGS-WRD, MA-RI District (hydrology protocol)

In addition to those listed above, the efforts described in this report and work plan depend on the dedicated efforts of a dynamic cadre of seasonal technicians, research assistants, graduate students, undergraduate student interns, and volunteers.

#### **IV. Reports, Publications, and Presentations**

##### Reports and Publications:

Bradley, M., C. LaBash, and P. August. 2004. Digital Mapping and Characterization of Intertidal Habitats in Wellfleet Harbor, Nauset Marsh, and Hatches Harbor, Cape Cod National Seashore. University of Rhode Island, Environmental Data Center, Kingston, RI. 9pp.

Colman, J.A, and J. P. Masterson. 2004. Monitoring Ground-Water Quality in Coastal Ecosystems. USGS Water Resources Discipline, Massachusetts-Rhode Island District, Northborough, MA. 102pp. DRAFT

Cook, R.P. and K. Boland. 2004a. Monitoring of pond breeding amphibians at Cape Cod National Seashore, 2003. Cape Cod National Seashore, Wellfleet, MA. 35pp.

Cook, R.P. and K. Boland. 2004b. A comparison of approaches to counting spotted salamander (*Ambystoma maculatum*) egg masses in vernal ponds. Herpetological Review (in press)

Cook, R.P., K. Boland, S. Kot, J. Borgmeyer, and M. Schult. 2004. Inventory and monitoring of aquatic turtles at Cape Cod National Seashore. Cape Cod National Seashore, Wellfleet, MA. 78pp plus appendices. DRAFT

DeSante, D. F., P. Pyle, and D. R. Kaschube. 2004. The 2003 Annual and Final Report of the Monitoring Avian Productivity and Survivorship (MAPS) Program on Cape Cod National Seashore. Institute for Bird Populations, Point Reyes, CA. 45pp plus appendices.

Gwilliam, E.L. 2004. Extent and Composition of Coastal Sandplain Plant Communities of the Cape Cod National Seashore. MS Thesis, University of Rhode Island, Kingston, RI. 70pp. DRAFT

Portnoy, J., C. Roman, S. Smith, and E. Gwilliam. 2003. Estuarine habitat restoration at Cape Cod National Seashore: The Hatches Harbor Prototype. *Park Science* 22:51-58.

Potash, V. and S. Huse. 2004. White Paper: Database Models for Fixed Location Monitoring. Cape Cod National Seashore and Northeast Coastal Barrier Network. 9pp.

Smith, S. 2004a. 2003 Salt Marsh Vegetation Monitoring Report. Cape Cod National Seashore, Wellfleet, MA. 43pp.

Smith, S. 2004b. Manual control of *Phragmites australis* (common reed) on pondshores of Cape Cod National Seashore, Massachusetts, USA. *Journal of Aquatic Plant Management* (in review)

Smith, S. and V. Potash. 2004. Coastal Forest Monitoring Protocol. Cape Cod National Seashore, Wellfleet, MA. 49pp plus appendices. DRAFT

S.M. Smith, R.M.M. Abed and F. Gercia-Pichel. 2004. Biological Soil Crusts of Sand Dunes in Cape Cod National Seashore, Massachusetts, USA. *Microbial Ecology* (in press)

Sneddon, L.A. and R.E. Zaremba. 2004. Vegetation classification of the Cape Cod National Seashore. NatureServe, Arlington, VA

#### Presentations:

Cook, R. 2004. Anuran Monitoring at Cape Cod National Seashore. Presentation at the Cape Cod Natural History Conference. Barnstable, MA.

Cook, R. 2004. Anuran Monitoring at Cape Cod National Seashore. Presentation at the annual meeting of the New England Chapter of the Society for Environmental Toxicology and Chemistry. Jamestown, RI.

Cook, R. 2004. Amphibians and Reptiles of Cape Cod National Seashore. Presentations to visitors at the Province Lands Visitor Center. Provincetown, MA.

Cook, R. 2004. Marsh Birds of Cape Cod National Seashore. Presentation at the Massachusetts Audubon Wellfleet Bay Wildlife Sanctuary. Wellfleet, MA.

Gwilliam, E. 2004. Geohydrology of Lower Cape Cod and Current Water Issues. Presentation to Bridgewater State College Hydrology Class. Bridgewater, MA.

Gwilliam, E. 2004. Extent and Composition of Coastal Sandplain Plant Communities of the Cape Cod National Seashore. Thesis Defense at URI Department of Natural Resource Science. Kingston, RI.

O'Connell, A. 2004. Monitoring Medium-Sized Mammals and Estimation of Detection Probability and Site Occupancy. Presentation at the Annual Meeting of the American Society of Mammalogists. Arcata, CA.

Phillips, C. 2003. Cape Cod National Seashore Prototype Inventory and Monitoring Program. Presentation to the Pleasant Bay Alliance. Harwich, MA.

Phillips, C. 2004. Cape Cod National Seashore Prototype Inventory and Monitoring Program. Presentation to the Nantucket Consortium of Naturalists. Nantucket, MA

Potash, V. 2004. 1: Software Options and Requirements for Image File Management  
2: Alternatives for the Event Table Structure for Monitoring Databases  
3: Image Linking and Record Selection in Database GUI Design  
Presentations at the I&M Data Managers Meeting, Las Vegas, NV.

Smith, S. 2004. Interdunal swales of Cape Cod National Seashore. Presentation at the URI Department of Natural Resources Science Seminar Series. Kingston, RI.

## V. Status of Park Vital Signs Monitoring

<b>Cape Cod National Seashore 2003</b>	Air Quality	Water Quality	Water Quantity	Geologic Resources	Plants	Animals	Landscape Characteristics
Planning and Design							
w/NRC funding		X		X	X	X	
w/other funding		X-c				X-c,d	X-c
Protocols Implemented							
w/NRC funding	X-a	X	X	X	X	X	X
w/other funding	X-a					X	
Analysis/Synthesis Available							
w/NRC funding					X	X	
w/other funding	X-b					X	

a-staff time supported by NRC funding; sample analysis supported by the Region

b-Nationwide syntheses are available from the NADP, MDN, and IMPROVE programs

c-development of the estuarine nutrient enrichment, estuarine benthic macrofauna, and visitor impact protocols are partially supported, by USGS Prototype Development funds

d-development of the freshwater fish and beach macroinvertebrate protocols are supported in part by NRPP funds

## VI. USGS Protocol Development and Monitoring-Related Research Needs

### Protocol Development:

We are interested in migrating from aerial photos to high-resolution satellite imagery as a platform for mapping and monitoring change in cover-types. We understand that several other parks and networks are interested in the same approach. USGS development of a protocol based on high-resolution satellite imagery and that cross-walk to our most recent aerial photo- and National Vegetation Classification System-based cover-type map would be valuable. If USGS pursues this project, it would be important to also investigate the utility of satellite imagery for monitoring change in inter- and sub-tidal cover-types.



#### Statistical Analysis Assistance:

Over the next several years, prototype parks and the first twelve networks will have collected enough data to support review of protocol design assumptions regarding inter-annual variation and power to detect trends across years. Expert assistance with these types of analyses and peer review of reports and protocol revisions based on examination of design assumptions will be critical. We recommend that USGS develop statistical analysis assistance and peer review program, that includes clear procedures for parks and networks to request this type of assistance, to meet what will be a growing need as the NPS I&M Program matures.

### **VII. Budget Narrative**

In FY2004, the Cape Cod Prototype Monitoring Program received the anticipated \$702,000 authorization for regular program expenses and operations. In addition, we also received \$44,800 from the Vegetation Mapping program for thematic accuracy assessment of the recently completed vegetation map. Just over 80 percent of these funds (91 percent of the \$702,000 base) were used to support permanent, term, and temporary staff as well as modest stipends and housing for volunteers. Our expenditures for personnel were higher than in previous years for two primary reasons. First, in FY2004 we were finally able to fill the Data Manager and Hydrology Tech positions. Both these positions are key to the program as we continue the transition from a developmental phase into an operational phase. Second, we required extensive and focused technical support from three Natural Resource Management staff on several high-priority projects: kettle pond water quality, cover-type change (vegetation map), hydrology, and laboratory method development. The amount of dedicated staff time needed from NRM was significant enough to warrant supporting a portion of those individuals' salary. FY2004 expenditures for cooperative agreements, and operations and equipment were lower than in FY2003. This is due to the shift away from new developmental projects that would normally be reflected through cooperative agreement expenditures, and reflects the equipment purchases and upgrades that occurred in previous years obviating the need for substantial new equipment expenditures in 2004.

We anticipate an authorization of \$702,000 again in FY2005. We estimate that about 88 percent of this budget will be dedicated to staff salaries and support for seasonal technicians and volunteers. This estimate reflects that FY2005 will be the first year the program will be fully staffed for the entire fiscal year, and that Cape Cod will be included in the Boston locality pay area beginning in January, 2005. Spending on cooperative agreements will only be for ongoing projects requiring additional funds or developmental work associated with the cover-type change or visitor use projects. As a result, we have again targeted only a small portion (about 1.4 percent) of our budget for agreements or contracts. We have planned for a slight increase in operations and equipment in anticipation of field meter and lab analysis needs associated with the estuarine nutrient enrichment and ground-water quality projects. We have also planned for a modest increase in travel. This is to support training for the new staff hired in 2004, and to increase communication and presentation of program results.

A summary of our FY2004 expenditures and F2005 budget plans is provided in the Budget Summary at the end of this report.

#### **VIII. References Cited (see also Section IV. Reports, Publications, and Presentations)**

Boland, K., R. Cook, E. Gwilliam, C. Phillips, J. Portnoy, and S. Smith. 2002. 2002 Update of the Conceptual Framework for the Development of Long-Term Monitoring Protocols at Cape Cod National Seashore. Cape Cod National Seashore, Wellfleet, MA. 74pp.

McCobb, T.D. and P.K. Weiskel. 2003. Long-Term Hydrologic Monitoring Protocol for Coastal Ecosystems. USGS Open-File Report 02-497. USGS, Massachusetts-Rhode Island District, Northborough, MA. 94pp.

National Park Service. 1998. Forging a Collaborative Future: General Management Plan for Cape Cod National Seashore. U.S. Department of Interior, National Park Service. 208pp.

Paton P.W.C, B. Timm, and T. Tupper. 2003. Monitoring Pond-Breeding Amphibians: A Protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. Technical Report, USGS Patuxent Wildlife Research Center, Coastal Field Station, Narragansett, RI. 113 pp.

Phillips, C. 2003. 2003 Cape Cod National Seashore LTEM Project Prioritization Report. Cape Cod National Seashore, Wellfleet, MA. 99pp.

Portnoy, J, K. Lee, J. Oset, E. Gwilliam, and J. Budreski. 2003. Water Quality Monitoring Protocol for Kettle Ponds of Cape Cod National Seashore. Cape Cod National Seashore, Wellfleet, MA. 52 pp.

Raposa, K.B. and C.T. Roman. 2001. Monitoring Nekton in Shallow Estuarine Habitats. Technical Report, USGS Patuxent Wildlife Research Center, Coastal Research Field Station, Narragansett, RI. 30pp.

Roman, C.T. and N.E. Barrett. 1999. Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, University of Rhode Island, Narragansett, RI. 59pp.

Roman, C., M. James-Pirri, and J. Heltshe. 2001. Monitoring Salt Marsh Vegetation: A Protocol for the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore. USGS Patuxent Wildlife Research Center, University of Rhode Island, Narragansett, RI. 47pp.

## Budget Summary

FY04 Admin Report

Network: Cape Cod NS Prototype

### Category: 1\_Income

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Authorization for FY2004	\$702,000.00	Prototype \$\$ - Park Base		
For Thematic Accuracy Assessment of Vegetation Map	\$45,800.00	Veg. Mapping Program		
<b>Subtotal</b>	<b>\$747,800.00</b>			

### Category: 2\_Personnel

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
a) Prototype Coordinator	\$89,295.00	Prototype \$\$ - Park Base	NPS	
b) Data Manager	\$59,837.00	Prototype \$\$ - Park Base	NPS	
c) Budget Tech	\$24,778.00	Prototype \$\$ - Park Base	NPS	
d) Wildlife Ecologist	\$85,237.00	Prototype \$\$ - Park Base	NPS	
e) Plant Ecologist	\$66,114.00	Prototype \$\$ - Park Base	NPS	
f) Aquatic Ecologist	\$58,115.00	Prototype \$\$ - Park Base	NPS	
g) Hydrology Tech	\$26,138.00	Prototype \$\$ - Park Base	NPS	
h) Wildlife Tech	\$35,999.00	Prototype \$\$ - Park Base	NPS	
i) Aquatic Ecology Tech	\$36,865.00	Prototype \$\$ - Park Base	NPS	
j) Laboratory Tech	\$34,774.00	Prototype \$\$ - Park Base	NPS	
k) Senior Ecologist	\$26,062.00	Prototype \$\$ - Park Base	NPS	
l) Chemist	\$29,346.00	Prototype \$\$ - Park Base	NPS	
m) GIS Specialist	\$29,594.00	Prototype \$\$ - Park Base	NPS	
n) Seasonal Tech - salt marsh vegetation	\$7,986.00	Prototype \$\$ - Park Base	NPS	
o) Seasonal Tech - amphibians	\$10,376.00	Prototype \$\$ - Park Base	NPS	
p) Seasonal Tech - GIS	\$6,105.00	Prototype \$\$ - Park Base	NPS	
q) Seasonal SCAs and VIPs	\$10,406.00	Prototype \$\$ - Park Base	NPS	
<b>Subtotal</b>	<b>\$637,027.00</b>			

**Category: 3\_Coop. Agreements**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
a) NatureServe - Vegetation Map Accuracy Assessment	\$44,800.00	Veg. Mapping Program	Other non-Federal	see expense 7a below
b) NatureServe - Vegetation Map Accuracy Assessment	\$975.00	Prototype \$\$ - Park Base	Other non-Federal	
c) Harvard Forest - Fresh Water Aquatic Invertebrate Project	\$3,734.00	Prototype \$\$ - Park Base	Univ_Non-CESU	
<b>Subtotal</b>	<b>\$49,509.00</b>			

**Category: 5\_Operations/Equipment**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
a) Field Equipment and Supplies	\$5,453.00	Prototype \$\$ - Park Base	Other non-Federal	
b) Laboratory Services, Equipment, and Supplies	\$37,242.00	Prototype \$\$ - Park Base	Other non-Federal	
c) Computer Hardware, Software, and Supplies	\$3,514.00	Prototype \$\$ - Park Base	Other non-Federal	
d) Office Supplies, Equipment, and Maintenance	\$1,385.00	Prototype \$\$ - Park Base	Other non-Federal	
e) Miscellaneous Supplies	\$2,606.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$50,200.00</b>			

**Category: 6\_Travel**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
Travel and Training	\$5,279.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$5,279.00</b>			

**Category: 7\_Other**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
a) Deduction by Region	\$1,000.00	Veg. Mapping Program	NPS	from WASO funds provided for vegetation map accuracy assessment
b) Miscellaneous Expenses	\$4,785.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$5,785.00</b>			

## Budget Analysis

### Analysis of Expenses by Where \$ Went

<b>Funding Source</b>	<b>Total \$\$</b>	<b>NPS</b>	<b>USGS</b>	<b>Other Federal</b>	<b>Univ.-CESU</b>	<b>Univ_Non-CESU</b>	<b>Other non-Federal</b>
Prototype \$\$ - Park Base	\$702,000	\$637,027				\$3,734	\$61,239
Veg. Mapping Program	\$45,800	\$1,000					\$44,800
<b>Totals</b>	<b>\$747,800</b>	<b>\$638,027</b>				<b>\$3,734</b>	<b>\$106,039</b>

### Analysis of Expenses by Category

<b>Funding Source</b>	<b>Total \$\$</b>	<b>Personnel:</b>	<b>Coop Agree.</b>	<b>Contracts</b>	<b>Operations/Equip.</b>	<b>Travel</b>	<b>Other</b>
Prototype \$\$ - Park Base	\$702,000	\$637,027	\$4,709		\$50,200	\$5,279	\$4,785
Veg. Mapping Program	\$45,800		\$44,800				\$1,000
<b>Totals</b>	<b>\$747,800</b>	<b>\$637,027</b>	<b>\$49,509</b>		<b>\$50,200</b>	<b>\$5,279</b>	<b>\$5,785</b>

### Expense Totals By Category

<b>Category</b>	<b>SubTotal</b>	<b>Percent</b>
2_Personnel	\$637,027	85.19%
3_Coop. Agreements	\$49,509	6.62%
5_Operations/Equipment	\$50,200	6.71%
6_Travel	\$5,279	0.71%
7_Other	\$5,785	0.77%
	<b>\$747,800</b>	

## Budget Summary

FY05 Work Plan

Network: Cape Cod NS Prototype

### Category: 1\_Income

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Anticipated Authorization for FY2005	\$702,000.00	Prototype \$\$ - Park Base		
<b>Subtotal</b>	<b>\$702,000.00</b>			

### Category: 2\_Personnel

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
a) Prototype Coordinator	\$97,211.00	Prototype \$\$ - Park Base	NPS	
b) Data Manager	\$74,910.00	Prototype \$\$ - Park Base	NPS	
c) Budget Tech	\$27,743.00	Prototype \$\$ - Park Base	NPS	
d) Wildlife Ecologist	\$92,501.00	Prototype \$\$ - Park Base	NPS	
e) Plant Ecologist	\$73,925.00	Prototype \$\$ - Park Base	NPS	
f) Aquatic Ecologist	\$66,213.00	Prototype \$\$ - Park Base	NPS	
g) Hydrology Tech	\$51,283.00	Prototype \$\$ - Park Base	NPS	
h) Aquatic Ecology Tech	\$41,108.00	Prototype \$\$ - Park Base	NPS	
i) Laboratory Tech	\$21,206.00	Prototype \$\$ - Park Base	NPS	
j) Seasonal Tech - Amphibian Monitoring 1	\$15,536.00	Prototype \$\$ - Park Base	NPS	
k) Seasonal Tech - Amphibian Monitoring 2	\$15,536.00	Prototype \$\$ - Park Base	NPS	
l) Seasonal Tech - Pond Vegetation Monitoring	\$8,366.00	Prototype \$\$ - Park Base	NPS	
m) Seasonal Tech - GIS	\$8,366.00	Prototype \$\$ - Park Base	NPS	
n) 5 Seasonal SCAs and/or VIPs	\$22,231.00	Prototype \$\$ - Park Base	NPS	
<b>Subtotal</b>	<b>\$616,135.00</b>			

### Category: 3\_Coop. Agreements

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
For Protocol Development or Related Studies	\$10,000.00	Prototype \$\$ - Park Base	University-CESU	
<b>Subtotal</b>	<b>\$10,000.00</b>			

**Category: 5\_Operations/Equipment**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
a) Field Equipment and Supplies	\$12,365.00	Prototype \$\$ - Park Base	Other non-Federal	
b) Laboratory Services, Equipment, and Supplies	\$39,000.00	Prototype \$\$ - Park Base	Other non-Federal	
c) Computer Hardware, Software, and Supplies	\$4,000.00	Prototype \$\$ - Park Base	Other non-Federal	
d) Office Supplies, Equipment, and Maintenance	\$1,500.00	Prototype \$\$ - Park Base	Other non-Federal	
e) Miscellaneous Operational Expenses	\$3,000.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$59,865.00</b>			

**Category: 6\_Travel**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
Travel and Training	\$11,000.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$11,000.00</b>			

**Category: 7\_Other**

<b>Description</b>	<b>\$ Amount</b>	<b>\$\$ Source</b>	<b>Where \$ Went</b>	<b>Comments</b>
Miscellaneous Expenses	\$5,000.00	Prototype \$\$ - Park Base	Other non-Federal	
<b>Subtotal</b>	<b>\$5,000.00</b>			

## Budget Analysis

### Analysis of Expenses by Where \$ Went

<i>Funding Source</i>	<i>Total \$\$</i>	<i>NPS</i>	<i>USGS</i>	<i>Other Federal</i>	<i>Univ.-CESU</i>	<i>Univ_Non-CESU</i>	<i>Other non-Federal</i>
Prototype \$\$ - Park Base	\$702,000	\$616,135			\$10,000		\$75,865
<b>Totals</b>	\$702,000	\$616,135			\$10,000		\$75,865

### Analysis of Expenses by Category

<i>Funding Source</i>	<i>Total \$\$</i>	<i>Personnel:</i>	<i>Coop Agree.</i>	<i>Contracts</i>	<i>Operations/Equip.</i>	<i>Travel</i>	<i>Other</i>
Prototype \$\$ - Park Base	\$702,000	\$616,135	\$10,000		\$59,865	\$11,000	\$5,000
<b>Totals</b>	\$702,000	\$616,135	\$10,000		\$59,865	\$11,000	\$5,000

### Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$616,135	87.77%
3_Coop. Agreements	\$10,000	1.42%
5_Operations/Equipment	\$59,865	8.53%
6_Travel	\$11,000	1.57%
7_Other	\$5,000	0.71%
	\$702,000	



## **Appendix I: Summary of Major Accomplishments and Findings of Interest**

The Prototype Monitoring Program at Cape Cod National Seashore focuses on monitoring issues most relevant to management of park resources, and uses an ecosystem approach to define monitoring questions and develop appropriate monitoring methods. We are currently transitioning from a developmental phase to an operational phase: of our twenty one high- and mid-priority monitoring projects, eight are now operational, protocols are being drafted for seven, and six are in development. USGS was our principal partner during the early developmental phase of the program; over the last few years, our range of partners expanded to include researchers from several universities and non-governmental organizations. The North Atlantic Coast Cooperative Ecosystems Studies Unit has played an important role in securing several of these partnerships. Many of our projects and partnerships have also been facilitated by collaboration and integration with the Atlantic Research Learning Center - another Natural Resource Challenge program located at Cape Cod National Seashore.

### FY2004 Objectives for Prototype Monitoring:

- Assess and monitor the integrity of estuarine and salt marsh ecosystems.
- Assess and monitor the integrity of beach, spit, and barrier island ecosystems.
- Assess and monitor the integrity of pond and freshwater wetland ecosystems.
- Assess and monitor the integrity of coastal upland ecosystems.
- Assess and monitor park-wide and multiple-system indicators of ecosystem integrity.
- Integrate monitoring efforts and results within and across ecosystems.
- Share information, report findings, and document program activities.
- Provide technical assistance to the Northeast Coastal and Barrier Network, to other networks and parks, and to other entities with common monitoring objectives.
- Develop and sustain a comprehensive data management program and appropriate staff resources, laboratory infrastructure, and programmatic procedures to ensure program objectives can be met now and into the future.

### Summary of Major Accomplishments and Findings of Interest During FY2004:

#### *Estuarine and Salt Marsh Ecosystems:*

In estuarine and salt marsh ecosystems, we implemented three long-term monitoring projects and assisted cooperators with four related projects. Restoration of tidally-restricted salt marshes is a major management focus at CACO. Estuarine and salt marsh elements of the Prototype Monitoring Program are designed to detect long-term change and to measure response to restoration actions. Highlights from this year's work in CACO's estuaries include:

Monitoring Vegetation Change in Restoring Salt Marshes: At two restoring salt marshes (Hatches Harbor and East Harbor) vegetation monitoring has captured several indicators of change in response to the return of tidal influence. Monitoring has documented the return of salt marsh species to formerly fresh or brackish areas, increased density and vigor of native salt marsh grasses, and decreased vigor in the fresh and brackish wetland plants that became established during the years tidal influence was

impaired. For example, vegetation monitoring has captured a decline in stem heights of the fresh and brackish wetland invasive exotic common reed *Phragmites australis* in Hatches Harbor (Figure 1). These data, coupled with the disappearance of *P. australis* from some plots, indicate vegetation response is on the desired trajectory and that these restoration projects are meeting ecosystem goals.

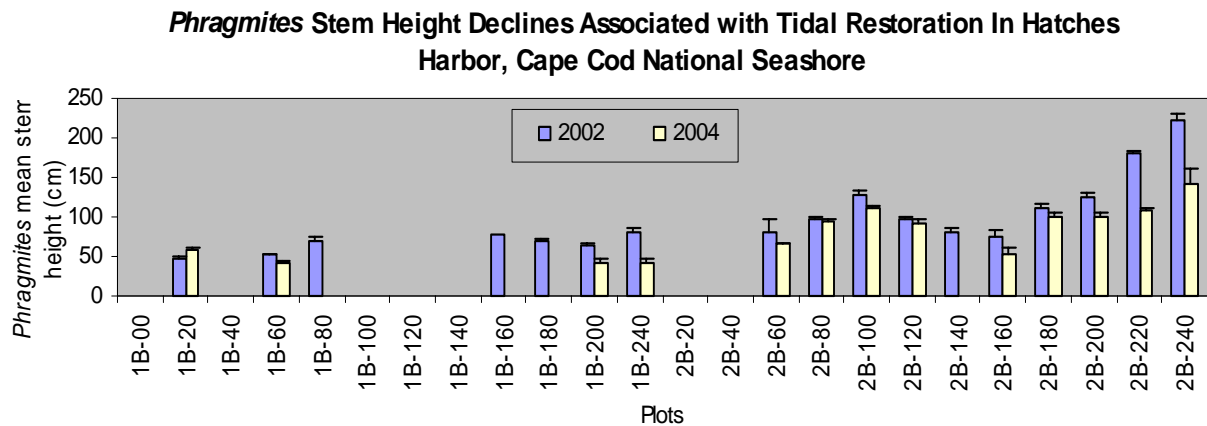


Figure 1. *Phragmites australis* stem heights along two transects (1B and 2B) in Hatches Harbor, Cape Cod National Seashore. Both transects are roughly perpendicular to the main restored tidal creek with the lowest numbered plots (1B-00 and 2B-20) closest to the creek.

Synthesizing Monitoring Results for Hatches Harbor: Results from sediment elevation, nekton, vegetation, and physical-chemical parameter monitoring in Hatches Harbor were synthesized into an overall assessment of system response to the phased tidal restoration underway since 1998. The results were published in an article in the fall 2003 edition of Park Science (Portnoy *et al.* 2003).

*Zostera marina* and Bivalves in East Harbor: East Harbor is a 717 acre back barrier estuary that was artificially isolated from Cape Cod Bay by construction of a dike in 1868. Following isolation, what had been a fully-tidal harbor was transformed into an artificial, fresh-water lake plagued by poor water quality, high turbidity, periodic fish kills, and dominated by exotic fish and plants. In 2001, Cape Cod National Seashore and the Town of Truro opened the tide gate in the culvert that drained the lake into Cape Cod Bay. This allows marine waters to reach the lake during rising tides. Since then, monitoring has documented improvements in water quality, vegetation changes, and the return of estuarine nekton and benthos. In 2004 there were two developments that underscore the recovery underway. First, during the course of salt marsh vegetation monitoring, biologists detected the eelgrass *Zostera marina*. Submerged aquatic vegetation in general, and *Z. marina* in particular, requires clear, clean water. The appearance of *Z. marina* in East Harbor confirms a biotic response to the improvement of water quality, particularly the increase in salinity and the decrease in turbidity. This also signals recovery of important ecosystem functions since *Z. marina* is a primary food source for brant and provides important habitat for a variety of marine species including crabs, shrimp, and the juvenile stages of commercially important finfish. The second

discovery of particular note is the return of hard clams (*Mercenaria mercenaria*), soft shelled clams (*Mya arenaria*), and blue mussels (*Mytilus edulis*). These species were detected during benthic community monitoring supported by the Atlantic Research Learning Center in collaboration with the Prototype Monitoring Program. These species also indicate improved sediment and water quality, and are of high cultural, recreational, and commercial importance on the outer Cape.



Figure 2. *Zostera marina* (left) and bivalves (right) in East Harbor. East Harbor was artificially isolated from Cape Cod Bay in 1868; marine influence was returned to the system in 2001; *Z. marina*, hard clams, soft shelled clams, and blue mussels were found in East Harbor in 2004. NPS Photos: *Z. marina*, Stephen Smith, Plant Ecologist; Bivalves, Katrina Lassiter, URI Coastal Fellow.

**Monitoring Salt Marsh Die-Back:** In 2003 in the Middle Meadow and The Gut marsh systems, the salt marsh vegetation monitoring project observed the first occurrence of salt marsh die-back in the park. Salt marsh die-back was first detected on the U.S. Atlantic coast in Georgia in 2001, and more recently it has been observed in marshes along the Connecticut and southern Cape Cod coasts. It is not known if this phenomenon is related to the “marsh browning” first detected in Louisiana salt marshes in 2000. In 2004, we initiated spatially-intensive monitoring of six randomly selected salt marsh die-back patches to capture any expansion or contraction and changes in surrounding vegetation. Photo points were also established at several other sites to detect any future occurrences of die-back. In addition to monitoring, we will be working with the Atlantic Research Learning Center to attract researchers interested in a more in-depth collaborative study on the extent, nature, and causes of salt marsh die-back on the Cape.

**Refining Estimates of Variance for Nekton Monitoring:** The estuarine nekton monitoring protocol being used by Cape Cod and the NCBN recommends that sampling occur every one to three years (Raposa and Roman 2001). This recommendation is based on values of inter-annual variation in the literature and sampling at five New England estuaries over one to two year periods. In FY2004, the Prototype Program and the NCBN initiated a

five-year program of annual sampling at Nauset Marsh to better estimate inter-annual variation. We anticipate that this project will support power analysis and enable us to refine recommendations in the protocol regarding sampling frequency.

*Beach, Spit, and Barrier Island Ecosystems:*

In FY2004, work in beach, spit, and barrier island systems remained focused on development of monitoring methods. We continued to provide assistance to the Northeast Coastal and Barrier Network in their efforts to develop a protocol for monitoring shoreline change. We also provided technical and logistical support to a study that is developing methods for monitoring the effects of disturbance on the threatened piping plover, evaluating the effects of disturbance to this species, and will assist interpretation of long-term plover monitoring data.

*Pond and Fresh-Water Wetland Ecosystems:*

In ponds and fresh-water wetland systems, our monitoring efforts focused on kettle pond water quality and pond-breeding amphibians. We also completed field work on a three-year study characterizing dune slack wetland systems. Some highlights from this year's work in fresh water systems include:

Testing periphyton as a measure of water quality: In previous years, kettle pond water quality monitoring included measuring chlorophyll as an indicator of biotic response to nutrient conditions. However, the dynamic and patchy distribution of phytoplankton within a pond and concerns about the reliability of field sampling and laboratory methods cast some doubt on the utility of this particular measure. This year, we began a testing the feasibility and utility of monitoring periphyton as an alternative to chlorophyll. Since standardized arrays of periphyton sampling surfaces can be deployed at multiple locations in a pond, and left in place for standardized periods of time, we anticipate that periphyton may provide an indicator of biotic response to nutrient conditions that is more reliably quantifiable, and that is spatially and temporally synoptic.

Documenting the success of *Phragmites australis* control methods: *P. australis*, an invasive exotic plant plaguing many of the Cape's impaired salt marshes, has also been found gaining a foothold in some of the park's fresh water systems. In 2003, manual removal below the water line was tested as a possible control technique along pond shores. Follow up monitoring in 2004 showed notable declines in both the extent and vigor of the treatment plots compared to untreated plots. The results have been written up for publication and are in review for the Journal of Aquatic Plant Management.

Increasing efficiency of amphibian egg mass monitoring methods: The pond-breeding amphibian monitoring protocol uses the locus method of obtaining egg mass counts. This method requires use of unique markers for each egg mass locus, and tracking egg mass totals on a per locus basis. This approach turned out to be extremely labor intensive both in the field and in managing and verifying data. In 2003, we implemented the locus method as called for in the protocol, and we also used a much simpler maximum count method. In 2004, the results of the two methods were compared, and the maximum count

method proved to sacrifice little in the way of accuracy compared to the significant gains in field and data management efficiency. A note on this comparison is currently in press in *Herpetological Review*.

#### *Coastal Upland Ecosystems:*

In coastal uplands, staff scientists made significant progress toward completion of the forest and coastal heathland vegetation monitoring protocols, and cooperators from USGS and the University of Massachusetts continued work on the meso-mammal and land-bird monitoring protocols. We also received the final report on a five year study monitoring avian productivity and survivorship carried out by the Institute for Bird Populations. 2004 was also the first field season for an inventory of northern harriers being conducted by Manomet Center for Conservation Sciences under a cooperative agreement established at the end of FY2003. Some highlights and notable findings include:

Characterizing microbiotic dune crusts: In 2003, the staff plant ecologist initiated a collaborative effort to characterize the community composition and ecological role of the park's microbiotic crusts dune crusts. In 2004, a paper on this project was published by *Microbial Ecology*. Co-authors were from the Max Planck Institute for Marine Microbiology in Bremen, Germany, and from Arizona State University.

Avian Productivity and Survivorship Study Indicates Possible Declines in Selected Land Bird Species: Toward the end of FY2004 we received the final report from the five-year project monitoring avian productivity and survivorship (MAPS) carried out by the Institute for Bird Populations. Results of note include:

- the mean annual index of total adult population size at CACO was 28% lower than at the seven other MAPS study sites along the Atlantic slope;
- nine of eleven target species and all species pooled showed declines over the five-year study period;
- six of eleven target species and all species pooled showed negative productivity trends over the five-year study period; and
- the negative trends in productivity suggest population declines may worsen in the near future.

We have yet to evaluate this report in depth, but these results indicate that land bird monitoring will be important to determine if these trends continue. Additional studies may also be needed to understand the causes of these declines and identify appropriate management actions.

#### *Park-Wide and Multiple-System Indicators:*

There are several key processes and attributes that influence all of the park's ecosystems and that need to be monitored in order to inform management decisions and interpret data from system-specific protocols; these include meteorologic processes, air quality, surface- and ground-water hydrology, and cover type. In FY2004, we collected basic meteorologic data and monitored atmospheric deposition, aerosols, and ozone as we have for the last several years. Under the technical leadership of the park's Chemist, we also continued the atmospheric mercury deposition monitoring initiated last year. We

continued collection of ground-water level and pond stage data, and began more in-depth field testing and trouble shooting on the surface flow portion of the hydrology protocol. The cooperators working on the vegetation and cover-type map (University of Massachusetts and NatureServe) completed the aerial photo interpretation and vegetation classification, and we initiated work with NatureServe to complete a thematic accuracy assessment. One highlight of note:

Vegetation Map Used to Assist Preparation of an EIS on Hunting Program: Though still undergoing an accuracy assessment, the vegetation map has already been put into use in support of management. In response to a law suit by the Humane Society, Fund for Animals, and several independent animal rights advocates, the park has been ordered to re-evaluate its hunting program and prepare an EIS. This is a highly controversial issue that has received national attention as well as intense local involvement. The vegetation map has been used as a base layer in displays designed to inform the public and solicit input during scoping. The data is also being used to develop and analyze the alternatives that will be evaluated in the EIS. The detailed, high quality information provided by the map will be critical to thorough analysis of alternatives and preparation of a strong, defensible EIS.